PATENT APPLICATION

PATENT AND TRADEMARK OFFICE

BEFORE THE HONORABLE BOARD OF PATENT APPEALS AND INTERFERENCES

In re the Application of

Alexander D. S. ELLIN et al.

On Appeal from Group: 1725

Application No.: 10/500,716

Examiner: S. HEINRICH

Filed: July 6, 2004

Docket No.: 120299

For: LASER MARKING

APPEAL BRIEF TRANSMITTAL

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Attached hereto is our Brief on Appeal in the above-identified application.

Also attached hereto is our Check No. 193926 in the amount of Five Hundred Dollars ($500.00) in payment of the Brief fee under 37 C.F.R. 41.20((b)(2). In the event of any underpayment or overpayment, please debit or credit our Deposit Account No. 15-0461 as needed in order to effect proper filing of this Brief.

Respectfully submitted,

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PATENT & TRADEMARK OFFICE

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BRIEF ON APPEAL

Appeal from Group 1725

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I. REAL PARTY IN INTEREST

The real party in interest for this appeal and the present application is Renishaw PLC, by way of an Assignment recorded in the U.S. Patent and Trademark Office at Reel 016022, Frame 0666.

II. <u>RELATED APPEALS AND INTERFERENCES</u>

There are no prior or pending appeals, interferences or judicial proceedings, known to Appellants, Appellants' representative, or the Assignees, that may be related to, or that will directly affect or be directly affected by or have a bearing upon, the Board's decision in the pending appeal.

III. STATUS OF CLAIMS

Claims 1-36, 42 and 43 are on appeal.

Claims 1-36, 42 and 43 are pending.

No claims are explicitly allowed. However, neither an objection nor a rejection was made to claims 42 and 43.

Claims 1-36 are rejected.

IV. STATUS OF AMENDMENTS

A Request for Reconsideration was filed in reply to the Final Rejection dated November 16, 2006. The Request for Reconsideration was considered as evidenced by the February 27, 2007 Advisory Action.

V. SUMMARY OF CLAIMED SUBJECT MATTER

The claims relate to a method and an apparatus that produce precision marks for a metrological scale. Instead of using a laser that generates relatively long pulses to produce scale markings, Appellants teach using a laser that emits "ultra-short" pulses. The ultra-short pulses remove material from a substrate by a different ablation mechanism than that which was previously used. In particular, such ultra-short pulses ablate material without the material passing through a molten stage (i.e., the material is sublimated or ejected from the surface as minute solid particles). Appellants can thus reduce thermal expansion effects that can be associated with using lasers that generate shorter pulses and therefore increase the accuracy of the scale that is produced.

According to a first exemplary aspect as recited in independent claim 1 and as illustrated in Figs. 1-3e, for example, a method of producing precision marks (28a-28e, Figs. 3a-3e) for a metrological scale (10), employing an apparatus including: a scale substrate (ribbon, paragraph [0027] of the U.S. Patent Application Publication No. 2005/0045586) to be marked at repeated instants by a laser (21, Fig. 2) and thereby forming a metrological scale (10); a laser (21) operable so as to provide light pulses for forming scale markings (28a-28e) at the substrate (ribbon); a displacement device (pinch rollers 20, 22, Fig. 2 and paragraphs [0031] and [0032]) for causing relative displacement between the substrate (ribbon) and the location at which the light is incident on the substrate (ribbon); and a controller (200, Fig. 1) for controlling the relative displacement and the laser (21), includes the steps, in any suitable order, of:

operating the displacement mechanism (pinch rollers 20, 22) so as to cause relative displacement between the substrate (ribbon) and the light (from laser 21);

using the controller (200) to control the relative displacement (paragraphs [0035] - [0037]) and to operate the laser (21) so as to produce light pulses at the substrate (ribbon), (as illustrated in Figs. 3a-3e);

characterized in that:

the laser (21) produces a plurality of ultra-short output pulses (pulse lengths below approximately 4 picoseconds) of a fluence (beam energy (F)) at the substrate (ribbon) such that the metrological scale marks (28a-28e) are formed by laser ablation (paragraph [0039]), wherein the plurality of ultra-short output pulses (pulse lengths below approximately 4 picoseconds) have a duration such that the scale markings (28a-28e) are formed on the scale substrate (ribbon) by a laser ablation mechanism in which the molten stage is omitted (paragraph [0062], parameters are all chosen to keep the temporary bulk temperature rise at the ablation area to less than about 6°C).

According to a second exemplary aspect as recited in independent claim 19 and as illustrated in Figs. 1-3e, for example, an apparatus for producing precision marks (28a-28e, Figs. 3a-3e) for a metrological scale (10) includes: a scale substrate (ribbon, paragraph [0027]) to be marked at repeated instants by a laser (21, Fig. 2) and thereby forming a metrological scale (10); a laser (21) operable so as to provide light pulses for forming scale markings (28a-28e) at the substrate (ribbon); a displacement device (pinch rollers 20, 22, Fig. 2 and paragraphs [0031] and [0032]) for causing relative displacement between the substrate (ribbon) and the location at which the light is incident on the substrate(ribbon); and a controller (200, Fig. 1) for controlling the relative displacement and for operating the laser (21) so as to produce light at the substrate (ribbon), characterized in that the pulses of light produced by the laser (21) are ultra-short pulses (pulse lengths below approximately 4 picoseconds) of a fluence (beam energy (F)) at the substrate (ribbon) such that the metrological scale marks (28a-28e) are formed by laser ablation (paragraph [0039]), wherein

the plurality of ultra-short output pulses (pulse lengths below approximately 4 picoseconds) have a duration such that the scale markings (28a-28e) are formed on the scale substrate (ribbon) by a laser ablation mechanism in which the molten stage is omitted (paragraph [0062], parameters are all chosen to keep the temporary bulk temperature rise at the ablation area to less than about 6°C).

VI. GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

The following grounds of rejection are presented for review:

1) Claims 1-36 were rejected under 35 U.S.C. §103(a) over Appellants' admitted prior art (AAPA) in view of DE 19608937 (DE '937), Cline et al. (Cline), U.S. Patent No. 6,066,830, Golker, U.S. Patent No. 4,406,939, and DE 3042650 (DE '650).

Neither an objection nor a rejection was made to claims 42 and 43. It is thus assumed that claims 42 and 43 contain allowable subject matter.

VII. ARGUMENT

The following grounds of rejection are presented for review:

1) Claims 1-36 were rejected under 35 U.S.C. §103(a) over Appellants' admitted prior art (AAPA) in view of DE 19608937 (DE '937), Cline et al. (Cline), U.S. Patent No. 6,066,830, Golker, U.S. Patent No. 4,406,939, and DE 3042650 (DE '650).

Neither an objection nor a rejection was made to claims 42 and 43. It is thus assumed that claims 42 and 43 contain allowable subject matter.

A. 35 U.S.C. §103(a) Obviousness

In the absence of an anticipatory prior art reference, the issue becomes whether "the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains." 35 U.S.C. §103(a). In determining obviousness, the following four factors must be considered: (1) the scope and content of the prior art; (2) any differences between the prior art and the claims at issue; (3) the level of ordinary skill in the pertinent art; and (4) any secondary considerations evidencing non-obviousness, such as commercial success, copying, long felt but unsolved needs, failures of others, unexpected results, etc. *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. ___, ___, 82 USPQ2d 1385, 1391 (2007), *citing Graham v. John Deere Co. of Kansas City*, 383 U.S. 1, 17-18 (1966).

In *KSR*, the Supreme Court confirmed that, in evaluating obviousness, "an expansive and flexible" approach is to be taken, *i.e.*, "rigid and mandatory formulas" are improper. 82 USPQ2d at 1395-97. More specifically, the Court indicated that combining prior art elements to perform their respective established functions is likely to be obvious when it does no more than yield predictable results. *Id.* at 1395. Indeed, if a design need or market pressure to solve a problem having a finite number of identified, predictable solutions provides good

reason for an ordinarily skilled person to pursue the known options within his or her technical grasp, and if such pursuit leads to the anticipated success, "it is likely the product not of innovation but of ordinary skill and common sense" and "[i]n that instance the fact that a combination was obvious to try might show that it was obvious under §103." *Id.* at 1397. Conversely, when the prior art teaches away from combining known elements, discovery of a successful way to combine them is more likely not obvious. *Id.* at 1395.

Obviousness is not shown merely by demonstrating that each of the elements of a claimed combination was known in the art. Rather, "it can be important to identify a reason that would have prompted a person of ordinary skill in the relevant field to combine [or modify] the elements" as claimed. *Id.* at 1396. However, "any need or problem known in the field of endeavor at the time of invention and addressed by the patent" can provide such a reason, as the patentee's particular motivation/purpose does not control. *Id.* at 1397. Also, a precise teaching of claimed subject matter is not needed, as familiar items have obvious uses beyond their primary purposes, and one must consider inferences/creative steps that a person of ordinary skill ("a person of ordinary creativity, not an automaton") would have employed. *Id.* at 1396-97.

A long-standing obviousness test used by the Federal Circuit is the "teaching-suggestion-motivation" (TSM) test, under which a patent claim is proved obvious only if a teaching, suggestion or motivation (*i.e.*, a reason) to combine or modify prior art teachings is found in the prior art, in the nature of the problem, or in the knowledge of a person of ordinary skill in the art. *Id.* at 1391. The Supreme Court in *KSR* confirmed that "[t]here is no necessary inconsistency between the idea underlying the TSM test and the *Graham* analysis," as long as the TSM test is not applied rigidly or narrowly. *Id.* at 1396-97. According to Federal Circuit decisions consistent with *KSR*, the motivation/suggestion/teaching may but need not be found explicitly in the prior art, and the prior art may but need not be combined

or modified for the same reasons contemplated by the inventor. *In re Kahn,* 441 F.3d 977, 987-88 (Fed. Cir. 2006) (cited with approval in *KSR*, *id.* at 1396). Furthermore, "prior art" is broader than just the references sought to be combined, and motivation may be established based upon, *inter alia,* basic principles, common knowledge and/or common sense. *DyStar Textilfarben GMBH & Co. Deutschland KG v. C.H. Patrick Co.,* 464 F.3d 1356, 1360-61, 1367 (Fed. Cir. 2006); *see also Alza Corp. v. Mylan Labs., Inc.*, 464 F.3d 1286, 1291, 1294 (Fed. Cir. 2006) (decisions cited by *KSR, id.* at 1397, as providing "a broader conception of the TSM test" than the Federal Circuit's erroneous application of the test in *KSR*). Regardless, however, a conclusion of obviousness should be explicitly supported by "articulated reasoning with some rational underpinning" and not "by mere conclusory statements." *See KSR, id.* at 1396, *quoting Kahn.*

The circumstances under which prior art may be found to "teach away" from a claimed combination are narrow, *e.g.*, a reference must lead one in a direction divergent from the path taken by a claimed invention and not just disclose an alternative or indicate that a claimed combination resolves a different problem or is less desirable, inefficient or inferior. *KSR, id.* at 1399; *Ormco Corp. v. Align Tech., Inc.*, 463 F.3d 1299, 1308 (Fed. Cir. 2006); *In re Fulton,* 391 F.3d 1195, 1200-01 (Fed. Cir. 2004); *Nat'l Steel Car Ltd. v. Can. Pac. Rwy. Ltd.,* 357 F.3d 1319, 1339 (Fed. Cir. 2004). Also, the "obvious to try" consideration mentioned in *KSR* dovetails with the motivation analysis in that a skilled artisan not only must have been motivated to combine or modify prior art to achieve a claimed invention, but also must have had a "reasonable expectation of success in doing so." *Pfizer, Inc. v. Apotex, Inc.,* 480 F.3d 1348, 1364-69 (Fed. Cir. 2007).

B. Claims 1-36 Are Not Obvious Over Appellants' Admitted Prior Art (AAPA) in view of DE 19608937 (DE'937), Cline et al. (Cline), U.S. Patent No. 6,066,830, Golker, U.S. Patent No. 4,406,939, and DE 3042650 (DE'650)

1. The References That Do Disclose A Metrological Scale Fail To Suggest Using Ultra-Short Pulses

None of the applied references disclose or suggest a method or an apparatus that combines both a metrological scale and ultra-short output pulses that are used to form precision markings on the metrological scale as recited in claims 1 and 19. In particular, none of the applied references disclose or suggest a method or an apparatus for producing precision marks with a laser that produces a plurality of ultra-short output pulses of a fluence at the substrate such that the metrological scale marks are formed by laser ablation, wherein the plurality of ultra-short output pulses have a duration such that the scale markings are formed on the scale substrate by a laser ablation mechanism in which the molten stage is omitted, as recited in claims 1 and 19.

The first category of applied references discussed below are those that are related to the manufacture of a metrological scale having precision scale markings (AAPA, DE '937 and Golker). The second category only includes Cline, which is the only reference that mentions ultra-short laser pulses. However, Cline teaches away from using ultra-short pulses. Reviewing the applied references as a whole, the use of ultra-short pulses to produce precision markings on a metrological scale is in no way obvious when the only reference that actually mentions ultra-short laser pulses leads one in a direction divergent from the path taken by claims 1 and 19.

Appellants do not discuss DE '650 because DE '650 was published in a foreign language and the previous Office Actions fail to particularly point out where DE '650 discloses any of the features recited in claims 1-36 even though Appellants repeatedly requested such description and clarification. The Advisory Action refers to the brief explanation provided by Appellants in the February 27, 2006 Information Disclosure Statement. However, that explanation, which was included with a foreign office action,

simply refers to DE '650. That explanation fails to discuss what DE '650 actually discloses or how DE '650 relates to claims 1-36. It is improper to maintain DE '650 when the Final Rejection cannot explain what DE '650 actually discloses.

a. AAPA Discloses Problems That Appellants Solve

The references cited in AAPA (U.S. Patent No. 4,932,131 and JP 5169286) state that it is known to form markings for a metrological scale using a laser. However, the references cited in AAPA fail to provide any disclosure or suggestion with regard to using a pulsed laser that generates short pulses or describe the process by which the mark is formed. In particular, the references cited in AAPA fail to disclose or suggest using ultra-short pulses or operating in a laser ablation regimen in which material is removed by a laser ablation mechanism in which the molten stage is omitted.

b. DE '937 Teaches Away From Using Ultra-Short Pulses

DE'937 discloses a method for marking a substrate using a pulsed laser. DE'937 uses an Excimer laser that produces pulses of approximately 20 ns (para. 4 of translation) and the laser pulse is used to melt the surface of the substrate (para. 8). The re-solidification of the melt provides a region of different surface roughness that has different optical properties to the surrounding material. Although DE'973 mentions that pulses of a much shorter duration can be used, the duration is selected in order to avoid heat dissipation from the process area (i.e. ensure that melting effect occurs efficiently).

As disclosed in DE'937, the laser pulse that is used to form scale marks must always be sufficiently long so that melting occurs. Otherwise, the re-solidification stage would not happen.

Pages 2 and 3 of the Final Rejection assert that DE'937 discloses a well known laser marking using an ultra-short pulse laser. However, no where in DE'937 is it stated that DE'937 uses ultra-short pulses, and the Final Rejection fails to specifically identify where

DE'937 states that ultra-short pulses are used. Furthermore, pulses of approximately 20 ns as used in DE'937 is not the same as ultra-short pulses as understood by a person of ordinary skill in the relevant field.

In addition, DE'937 explicitly requires a melting effect to occur. Because a melting effect is explicitly required, one skilled in the art reading DE'937 would have actually been led away from using ultra-short pulses having a duration such that the scale marks are formed on a scale substrate by a laser ablation mechanism in which the molten stage is omitted, as recited in claims 1 and 19.

c. Golker Fails To Disclose Using A Pulsed Laser, and thus fails to suggest using Ultra-Short Pulses

Golker discloses various methods for manufacturing a code disk for encoders. Golker discloses connecting a code disk to be marked to an angle measuring device. The code disk is then rotated and a laser is fired to mark the code disk when certain angular positions are reached. Although the laser is switched on an off to mark the required pattern on the code disk, Golker fails to provide any disclosure or suggestion with regard to using short or ultra-short laser pulses. Golker's laser is a standard CW (i.e. non-pulsed) laser that is switched on and off and is not a pulsed laser capable of producing ultra-short pulses.

Because Golker fails to disclose using a pulsed laser, and thus fails to suggest using ultra-short pulses, Golker fails to provide any reason that would have prompted a person of ordinary skill in the relevant field to use ultra-short output pulses or operating in a laser ablation regimen in which material is removed by a laser ablation mechanism in which the molten stage is omitted, as recited in claims 1 and 19.

2. The Only Reference That Mentions Ultra-Short Pulses Teaches Away From Using Ultra-Short Pulses

Taking the disclosures of AAPA, DE'937 and Golker as a whole, there is no disclosure with regard to using ultra-short laser pulses. Because there is no disclosure with

regard to using ultra-short laser pulses, there is no reason that would have prompted a person of ordinary skill in the relevant art to use ultra-short pulses having a duration such that the scale marks are formed on a scale substrate by a laser ablation mechanism in which the molten stage is omitted, as recited in claims 1 and 19. The only reference remaining, Cline, fails to overcome the deficiencies of AAPA, DE'937 and Golker.

The second category only includes Cline, which illustrates a pulsed laser system that can produce ultra-short laser pulses. However, Cline fails to disclose or suggest using ultra-short pulses to form precision markings on a metrological scale. Cline discloses a method of laser etching that can be used to form electroluminescent structures. In particular, the method is directed to depositing certain layers (i.e., electrodes) and then selectively removing the layers to provide the required electrode pattern using laser pulses (col. 6, lines 38-44). Although Cline mentions that a titanium sapphire laser (which is capable of producing ultra-short pulses) can be used (col. 7, line 4), Cline states that such a laser is less effective than Nd:YAG lasers or the like (col. 6, line 67) that typically generate longer pulses.

Cline thus teaches away from using ultra-short pulses because Cline explicitly states that the use of a titanium sapphire laser (which is capable of producing ultra-short pulses) is less effective, and is thus inferior to using longer pulses. In other words, the only reference that mentions a laser that produces ultra-short pulses actually teaches away from using ultra-short pulses.

Because Cline teaches away from using ultra-short pulses, Cline fails to provide any disclosure as to how the ultra-short pulses are controlled. In other words, Cline also fails to provide any reason that would have prompted a person of ordinary skill in the relevant field to operate in a laser ablation regimen in which material is removed by a laser ablation mechanism in which the molten stage is omitted, as recited in claims 1 and 19.

3. <u>The Applied Art As A Whole Fails To Suggest Trying The Combination Of Features</u>

The February 27, 2007 Advisory Action asserts that Appellants' argument is attempting to show non-obvious by attacking references individually. Appellants disagree and assert that the applied references as a whole fail to disclose or suggest all of the features recited in independent claims 1 and 19.

Taken as a whole, AAPA, DE'937 and Golker fail to disclose or suggest using ultra-short pulses. Cline, which does not disclose using a metrological scale, teaches away from using ultra-short pulses. Accordingly, if one of ordinary skill in the relevant field were to combine the teachings of Cline with either of AAPA, DE'937 and Golker, a person of ordinary skill in the relevant field would avoid using ultra-short pulses because Cline explicitly states that the use of ultra-short pulses is less effective. In other words, there is no reason that would have prompted a person of ordinary skill in the relevant field to use ultra-short pulses from Cline in either AAPA, DE'937 and Golker when Cline only discusses the disadvantages of using ultra-short pulses.

Because Cline explicitly states that the use of ultra-short pulses is less effective, Cline in combination with either AAPA, DE'937 and Golker would provide no reason to operate in a laser ablation regimen in which material is removed by a laser ablation mechanism in which the molten stage is omitted, as recited in claims 1 and 19.

As previously discussed, the use of ultra-short pulses to produce precision markings on a metrological scale is in no way obvious in view of the documents contained in the first category (AAPA, DE '937 and Golker). Even if one skilled in the art were to have also looked to Cline (which Appellants assert would <u>not</u> have been obvious), the use of ultra-short pulses is discouraged.

Accordingly, the Office Action has failed to provide any reason why one of ordinary skill in the art would have derived the combination of features recited in claims 1 and 19 from the applied references in the above-identified first and second categories. Appellants also observe the following:

(a) None of the applied references in the first category refer to Cline, and vice versa. Thus, there would have been no reason whatsoever for a person of ordinary skill in the art to have consulted Cline.

(b) Even if Cline was consulted by one of ordinary skill in the art (which Appellants assert would not have been obvious), none of the applied references explicitly mention the use of ultra-short laser pulses to generate scale markings or the like. In fact, Cline actually teaches away from the use of ultra-short pulses by stating that Nd:YAG lasers are preferred to titanium sapphire lasers (col. 6, line 62 - col. 7, line 4). Motivation thus does not exist from the applied references to consider applying the ultra-short laser system teachings or methods in order to produce a metrological scale.

(c) Any assertion that the applied references would be combined to yield the combination of features recited in claims 1 and 19 is based purely on hindsight. Numerous types of laser systems exist, each producing laser radiation having different properties. The combination of features recited in claims 1 and 19 was developed by the Appellants' novel and non-obvious concept that thermal expansion effects can degrade the precision of metrological scale production and that such effects can be overcome using ultra-short laser pulses. The combination of applied references presented in the Final Rejection is thus based purely on hindsight analysis after gaining knowledge from Appellants' specification.

Accordingly, the combination of features recited in independent claims 1 and 19 are neither disclosed nor suggested by the applied art, nor is there any motivation provided in order to create the combination of features recited in claims 1 and 19.

4. Dependent Claims 2-18 and 20-36 Are Not Addressed

The November 16, 2006 Final Rejection broadly refers to the applied references. The November 16, 2006 Final Rejection fails to reasonable convey to Appellants where in the applied references the features recited in dependent claims 2-18 and 20-36 are disclosed. For example, none of the applied references identify, nor does the Final Rejection identify, the bulk temperature of claims 2, 4, 20 and 22, the marks of claims 3 and 21, or the optically contrasting marks of claims 5 and 23, as well as the additional features recited in the other dependent claims.

Accordingly, the combination of applied references fails to disclose or suggest all of the features recited in claims 2-18 and 20-36 and the Final Rejection fails to reasonably convey to Appellants where the applied references disclose all of the features recited in dependent claims 2-18 and 20-36.

5. Conclusion

As discussed above, the subject matter of claims 1-36 would not have been rendered obvious by the cited references. For this additional reason, Appellants respectfully request that the rejection be reversed.

VIII. CONCLUSION

For all of the reasons discussed above, it is respectfully submitted that the rejection is in error and that claims 1-36, 42 and 43 are in condition for allowance. For all of the above reasons, Appellants respectfully request this Honorable Board to reverse the rejections of claims 1-36.

Respectfully submitted,

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APPENDIX A - CLAIMS APPENDIX

CLAIMS INVOLVED IN THE APPEAL:

1. A method of producing precision marks for a metrological scale, employing apparatus including: a scale substrate to be marked at repeated instants by a laser and thereby forming a metrological scale; a laser operable so as to provide light pulses for forming scale markings at the substrate; a displacement device for causing relative displacement between the substrate and the location at which the light is incident on the substrate; and a controller for controlling the relative displacement and the laser,

the method comprising the steps, in any suitable order, of:

operating the displacement mechanism so as to cause relative displacement between the substrate and the light;

using the controller to control the relative displacement and to operate the laser so as to produce light pulses at the substrate;

characterised in that:

the laser produces a plurality of ultra-short output pulses of a fluence at the substrate such that the metrological scale marks are formed by laser ablation, wherein the plurality of ultra-short output pulses have a duration such that the scale markings are formed on the scale substrate by a laser ablation mechanism in which the molten stage is omitted.

2. A method of producing precision marks for a metrological scale as claimed in claim 1 wherein the substrate is subjected to a bulk temperature rise not exceeding about 6 degrees Celsius at the ablation area as a result of the ablation.

3. A method of producing precision marks for a metrological scale as claimed in claim 1 wherein the marks produced contrast optically with unablated substrate.

4. A method of producing precision marks for a metrological scale as claimed in claim 1 wherein the substrate is subjected to a bulk temperature rise causing thermal expansion uncertainties at the substrate ablation area below 3 parts per million.

5. A method of producing precision marks for a metrological scale as claimed in claim 3 wherein the optically contrasting marks have an altered reflectivity.

6. A method of producing precision marks for a metrological scale as claimed in claim 5 wherein the reflectivity of the marks is 3 or more times less than the reflectivity of the substrate.

7. A method of producing precision marks for a metrological scale as claimed in claim 1 wherein the substrate is flexible.

8. A method of producing precision marks for a metrological scale as claimed in claim 1 wherein the substrate is elongate.

9. A method of producing precision marks for a metrological scale as claimed in claim 8 wherein the substrate is a continuous metallic ribbon.

10. A method of producing precision marks for a metrological scale as claimed in claim 1 wherein the substrate is of a thickness of less than about 6 mm.

11. A method of producing precision marks for a metrological scale as claimed in claim 10 wherein the substrate is of a thickness of less than about 1 mm.

12. A method of producing precision marks for a metrological scale as claimed in claim 1 wherein the said displacement is continuous.

13. A method of producing precision marks for a metrological scale as claimed in claim 1 wherein the fluence at the centre center of the incidence is above the threshold for causing ablation by a factor of about 4 to about 12.

14. A method of producing precision marks for a metrological scale as claimed in claim 13 wherein the fluence at the centre of the incidence is above the threshold for causing

ablation by a factor of about e^2, wherein e is a mathematical constant for a base of natural logarithms.

15. A method of producing precision marks for a metrological scale as claimed in claim 1 further employing a laser light manipulation device, a displacement sensor for sensing the displacement between the substrate and the location at which the light is incident and a reader for determining the distance between two or more markings at the scale wherein the method further comprises:

issuing a signal from the displacement sensor to the controller;

issuing a signal from the reader to controller;

in response to the signals from the sensor and the reader using the controller to control the manipulation device, the displacement, and the repeated instants at which the laser ablates the substrate.

16. A method of producing precision marks for a metrological scale as claimed in claim 15 wherein the displacement is linear movement in one direction and the light manipulation device is operable to cause the location at which laser light is incident at the substrate to move transversely to the said direction.

17. A method of producing precision marks for a metrological scale as claimed in claim 15 wherein the controller is used to further control the manipulation and/or displacement according to known apparatus error information.

18. A method of producing precision marks for a metrological scale as claimed in claim 1 wherein the laser light is formed as at least one ellipse where the light is incident the substrate.

19. Apparatus for producing precision marks for a metrological scale comprising: a scale substrate to be marked at repeated instants by a laser and thereby forming a metrological scale; a laser operable so as to provide light pulses for forming scale markings at

the substrate; a displacement device for causing relative displacement between the substrate and the location at which the light is incident on the substrate; and a controller for controlling the relative displacement and for operating the laser so as to produce light at the substrate, characterised in that the pulses of light produced by the laser are ultra-short pulses of a fluence at the substrate such that the metrological scale marks are formed by laser ablation, wherein the plurality of ultra-short output pulses have a duration such that the scale markings are formed on the scale substrate by a laser ablation mechanism in which the molten stage is omitted.

20. Apparatus for producing precision marks for a metrological scale as claimed in 19 wherein the substrate is subjected to a bulk temperature rise not exceeding about 6 degrees Celsius at the ablation area as a result of the ablation.

21. Apparatus for producing precision marks for a metrological scale as claimed in claim 19 wherein the marks produced contrast optically with unablated substrate.

22. Apparatus for producing precision marks for a metrological scale as claimed in claim 19 wherein the substrate is subjected to a bulk temperature rise causing thermal expansion uncertainties at the substrate ablation area below 3 parts per million.

23. Apparatus for producing precision marks for a metrological scale as claimed in claim 21 wherein the optically contrasting marks have an altered reflectivity.

24. Apparatus for producing precision marks for a metrological scale as claimed in claim 23 wherein the reflectivity of the marks is 3 or more times less than the reflectivity of the substrate.

25. Apparatus for producing precision marks for a metrological scale as claimed in claim 19 wherein the substrate is flexible.

26. Apparatus for producing precision marks for a metrological scale as claimed in claim 19 wherein the substrate is elongate.

27. Apparatus for producing precision marks for a metrological scale as claimed in claim 26 wherein the substrate is a continuous metallic ribbon.

28. Apparatus for producing precision marks for a metrological scale as claimed in claim 19 wherein the substrate is of a thickness of less than about 6 mm.

29. Apparatus for producing precision marks for a metrological scale as claimed in claim 28 wherein the substrate is of a thickness of less than about 1 mm.

30. Apparatus for producing precision marks for a metrological scale as claimed in claim 19 wherein the said displacement is continuous.

31. Apparatus for producing precision marks for a metrological scale as claimed in claim 19 wherein the fluence at the centre center of ablation is above the threshold for causing ablation by a factor of 4 to 12.

32. Apparatus for producing precision marks for a metrological scale as claimed in claim 31 wherein the fluence at the centre of ablation is above the threshold for causing ablation by a factor of e^2, wherein e is a mathematical constant for a base of natural logarithms.

33. Apparatus for producing precision marks for a metrological scale as claimed in claim 19 further comprising a laser light manipulation device, a displacement sensor for sensing the displacement between the substrate and the location at which the light is incident and for issuing a signal from the displacement sensor to the controller and a reader for determining the distance between two or more markings at the scale and for issuing a signal from the reader to controller, the controller being further operable in response to the signals from the sensor and the reader so as to control the manipulation device, the displacement, and the repeated instants at which the laser ablates the substrate.

34. Apparatus for producing precision marks for a metrological scale as claimed in claim 33 wherein the displacement is linear movement in one direction and the light

manipulation device is operable to cause the location at which laser light is incident at the substrate to move transversely to the said direction.

35. Apparatus for producing precision marks for a metrological scale as claimed in claim 33 wherein the controller is used to further control the manipulation and/or displacement according to known apparatus error information.

36. Apparatus for producing precision marks for a metrological scale as claimed in claim 19 wherein the laser light is formed as at least one ellipse at the area where the light is incident at the substrate.

42. A method of producing precision marks for a metrological scale as claimed in claim 1 wherein the ultra-short pulses have a duration of less that 4 picoseconds.

43. Apparatus for producing precision marks for a metrological scale as claimed in 19 wherein the ultra-short pulses have a duration of less that 4 picoseconds.

APPENDIX B - EVIDENCE APPENDIX

NONE

APPENDIX C - RELATED PROCEEDINGS APPENDIX

NONE